A low energy two-stage technology for leachate valorisation

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In the EU, annually 16 tonnes of materials are used by each person and 6 tonnes of it are converted into waste.

Solid waste can be disposed in various ways:

- Incineration.
- Landfilling.
- Recycling.
- Composting.

Landfilling has been the most commonly used solid waste disposal, especially in the Mediterranean and Eastern Europe countries.

Landfills present long-term threats to soil, air, groundwater and surface water due formation of greenhouse gases (methane gas and carbon dioxide from decomposing garbage) and leachate.
Background

Municipal waste generation and treatment, EU-27 (Source: Eurostat, 2017)
Leachate

- Leachate is the liquid fraction of the already existing moisture/liquid within the solid waste and the continuously formed liquid with dissolved and suspended solids extracted from the waste while rainfall percolates through it.

- Not only during their useful life, but also fifty years after their closure, landfills keep on producing leachate.

- Approximately, 10 m$^3$ of leachate is generated per 115 tonnes of solid waste.

- The composition of leachate differs from site to site and also within the landfill, the composition of the leachate alters with time (from weeks to years).
The composition of the leachate depends on factors such as characteristics of the waste:

- moisture content.
- climatic conditions.
- degree of compaction.
- age of the landfill.

Therefore, the leachate composition cannot be generalised and an unique treatment option cannot be suggested.
Although leachate composition varies from one to the other, what they have in common is hazardous constituents and their potential ecotoxicological effects on human and on terrestrial ecosystems.

The main leachate components are:

- Dissolved Organic Compounds.
- Inorganic components.
- Heavy Metals.
- Xenobiotic organic compounds.
General leachate composition with respect to leachate age (Source: Stegmann et al., 2005)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acid phase (younger)</th>
<th>Methanogenic phase (older)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.2-7.8</td>
<td>7.0-8.3</td>
</tr>
<tr>
<td>BOD₅ (mg/L)</td>
<td>600-27,000</td>
<td>20-700</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>950-40,000</td>
<td>460-8,300</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>350-12,000</td>
<td>150-1,600</td>
</tr>
<tr>
<td>NH₄-N (mg/L)</td>
<td>17-1,650</td>
<td>17-1,650</td>
</tr>
<tr>
<td>TKN</td>
<td>250-2,000</td>
<td>250-2,000</td>
</tr>
<tr>
<td>SO₄ (mg/L)</td>
<td>35-925</td>
<td>25-2,500</td>
</tr>
<tr>
<td>Total P (mg/L)</td>
<td>0.3-54</td>
<td>0.3-54</td>
</tr>
<tr>
<td>Na (mg/L)</td>
<td>1-6,800</td>
<td>1-6,800</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>170-1,750</td>
<td>170-1,750</td>
</tr>
<tr>
<td>Mg (mg/L)</td>
<td>30-600</td>
<td>25-300</td>
</tr>
<tr>
<td>Ca (mg/L)</td>
<td>80-2,300</td>
<td>50-1,100</td>
</tr>
<tr>
<td>Fe (mg/L)</td>
<td>3-500</td>
<td>4-125</td>
</tr>
<tr>
<td>Zn (mg/L)</td>
<td>0.05-16</td>
<td>0.09-3.5</td>
</tr>
<tr>
<td>Cr (mg/L)</td>
<td>0.002-0.52</td>
<td>0.002-0.52</td>
</tr>
<tr>
<td>Cl (mg/L)</td>
<td>315-12,400</td>
<td>315-12,400</td>
</tr>
<tr>
<td>Ni (mg/L)</td>
<td>0.01-1</td>
<td>0.01-1</td>
</tr>
<tr>
<td>Cu (mg/L)</td>
<td>0.005-0.56</td>
<td>0.005-0.56</td>
</tr>
<tr>
<td>As (mg/L)</td>
<td>0.0053-0.11</td>
<td>0.0053-0.11</td>
</tr>
<tr>
<td>Hg (mg/L)</td>
<td>0.00002-0.025</td>
<td>0.00002-0.025</td>
</tr>
<tr>
<td>Pb (mg/L)</td>
<td>0.008-0.4</td>
<td>0.008-0.4</td>
</tr>
<tr>
<td>Cd (mg/L)</td>
<td>0.0007-0.525</td>
<td>0.0007-0.525</td>
</tr>
</tbody>
</table>
In the absence of treatment, leachate is:

- Recycled back to the waste to maintain the biological activity in the composting solid waste by keeping it moist.
- Send it to sewer or to a wastewater treatment plant (WWTP) in case they do not treat it on site.

Leachate treatment processes comparative costs (Source: Adapted from Giraldo, 2001)

<table>
<thead>
<tr>
<th>Treatment technology</th>
<th>Cost (€/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic process with nitrogen removing</td>
<td>15.00</td>
</tr>
<tr>
<td>Two steps reverse osmosis</td>
<td>7.50</td>
</tr>
<tr>
<td>Biologic process + carbon activated + precipitation</td>
<td>18.75-26.25</td>
</tr>
<tr>
<td>Biologic process + reverse osmosis + concentrate evaporation</td>
<td>26.25-30.00</td>
</tr>
<tr>
<td>LIFE LEACHLESS technology (solar evaporation/condensation + forward osmosis)</td>
<td>4.75</td>
</tr>
</tbody>
</table>
LIFE LEACHLESS project demonstrates the feasibility of an innovative in-situ treatment process for leachates generated in landfills and waste treatment plants.

The project LIFE LEACHLESS proposes a sustainable management composed of specially designed solar panels, which reach to very high temperatures to evaporate the leachate.

Then the vapour is condensed to follow its path through forward osmosis (FO) step. FO requires less energy than the reverse osmosis (RO) and has less fouling problems.

The project is easy to replicate and easy to operate and maintain.

The proposed system is a universal solution independent of the leachate composition.
The LIFE LEACHLESS project will promote water resources management actions in accordance with the Water Framework Directive 2000/60/EC by enabling managers of landfills and waste treatment centres to achieve good qualitative and quantitative status of their effluents.

The LEACHLESS project proposes a treatment model that will be carried out "in-situ" using a cost-effective novel technology that combines solar evaporation/condensation plus forward osmosis. The prototype will be powered by renewable energies (solar energy, biomass and residual heat), which will minimise the carbon footprint of the process.

The final effluents will be reused for cleaning and gardening purposes. A minority semi-solid residual stream will be also generated in the process. Due to its special composition (rich in metals and inorganic elements), this stream will be valorised in ceramic industries to improve the final products characteristics.
The figures of the project

**Start:** 01/10/2016  
**End:** 31/12/2019  
**Duration:** 39 months

**Total budget:** 1,775,805 €

**EU contribution:** 1,041,237 €  
(60% of eligible budget)

**4 partners**
Process diagram

Leachate

Solar evaporation and condensation

Liquid fraction

Semisolid fraction

Forward osmosis

Liquid fraction

Semisolid fraction

Reuse for cleaning and gardening

Ceramic industry
The proposed treatment system is composed of two main separation processes:

- **a novel solar panel**, which evaporates and condenses the leachate in the first step.
- **forward osmosis** step to obtain effluent complying with the reuse standards.

This system will be placed in two containers, each with dimensions 12mx2.4mx2.9m, for the easy portability between the demonstrations sites:

- a **waste treatment centre** in Spain.
- a **landfill** in Greece.

The maximum **capacity** of the plant is **15 m³/day**.
A: Preparatory actions
   A1: Information / consultation to stakeholders
   A2: Administrative authorisation
   A3: Characterisation of leachate streams with different origin
   A4: Optimising the operating conditions of the individual technologies at laboratory scale

B: Implementation actions
   B1: Energy requirement analysis of individual processes
   B2: Prototype design and construction
   B3: Prototype start-up, validation and operation (Spanish demonstrator)
   B4: Prototype installation operation and optimisation (Greek demonstrator)
   B5: Training for pilot operators, maintenance workers and host facility owners
   B6: Assessment of effluent and sludge quality according final use
   B7: Suggestions for model implementation in follower facilities

C: Monitoring of the impact of the project actions
   C1: Monitoring and overall evaluation of the project
   C2: Monitoring the socio-economic impact of the project actions

D: Public awareness and dissemination of results
   D1: Dissemination planning and execution

E: Project management
   E1: Coordination and management of the project
   E2: Indicators
   E3: Audit
   E4: After-LIFE Plan
The first demo site selected is the SECOMSA’s Waste Treatment Centre in Catalonia (Spain):
The first demo site selected is the SECOMSA’s Waste Treatment Centre in Catalonia (Spain):
The second demo site selected is the Ano Liosia landfill in Athens (Greece):
Expected results

- Treatment up to 15 m³/day of leachate in a prototype introduced in containers for easy transport and installation, that allows flexibility in operating conditions.

- To obtain a high quality final effluent, 100% free of pathogens and xenobiotic compounds that can be reused or discharged into watercourses.

- To reduce the cost of leachate treatment over 80% when comparing with a traditional leachate treatment plant, by using solar radiation, biomass and residual heat as energy sources.

- To reduce by 80 to 90% the environmental impact associated with leachate streams proceeding from waste disposal in landfills or waste treatment centres.

- To eliminate the need of leachate transport to municipal wastewater treatment plants (WWTPs) and thereby, to eliminate the associated transport costs and the risk of emerging pollutants from leachate entering the overall water circuit and carbon footprint.
Expected results

- To have a **technology applicable** in those European countries (members and candidates) with the highest volume of municipal waste sent to landfill, which are also those, which most leachate generate. These countries (Spain, Greece, Italy, Portugal, Malta, etc.) are themselves the ones with the higher number of sunlight hours, which favours the operation of such technology.

- Improving the operation of landfills and **reducing** the associated **environmental impact** (contributing to the increased number of landfill adapted to the waste disposal Directive, 1999/31/CE).

- **100% valorisation** of the by-products generated in the process. The amount of sludge generated as a by-product is very low (1-3% of the total volume of leachate). However, the sludge generated can be valorised since it is interesting for the ceramic industry.
Expected results

- 60% reduction of the leachate storage reservoir size in landfills and waste treatment plants. Pollution removal at the source.

- Dissemination of good practices. Creation of a network of contacts for disseminating project results and extending the project scope.

- 2 replication studies for transferring the project findings in 2 “follower facilities” (1 in Spain and 1 in Greece) and 1 in Pordenone’s landfill in Italy when the project is completed.

- LIFE LEACHLESS will allow the authorities to increase the competitiveness and improving environmental legislation by better management of leachate.

- Dissemination of project results at national and international level through the Dissemination Plan.
Thank you for your attention
If you have any question, do not hesitate to contact me

More information:

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